

REMARKS

As an initial matter, Applicants gratefully acknowledge the Examiner's determination that claim 38 is allowed (Office Action, dated September 25, 2001, page 5, line 5).

Claims 25-28, 30, 32-35 and 39-48 have been canceled and claims 49-60 have been added; therefore, claims 29, 31, 36-38, and 49-60 are pending. Specifically, claims 49-54 respectively incorporate the subject matter of claims 32-37 in a dependent manner upon claim 38. Claims 55-60 incorporate in a respective fashion the subject matter of claims 25-28, 30 and 31 in a dependent manner upon claim 29. Applicants believe that the present amendment adds no new matter to the application.

Applicants assert that claims 29, 31, 36-38 and 49-60 are in condition for allowance for the forgoing reasons. Furthermore, Applicants assert that claims 25-28, 30, 32-35 and 39-48 have been canceled without prejudice and Applicants reserve the right to file a divisional and/or continuation application from either the present application or any one of the co-pending applications 09/543,247, 09/785,194, 09/785,436, and 09/785,486 having the same disclosure.

The Invention

The present invention pertains generally to a semiconductor device having a support member to which a semiconductor die or chip is attached using a die-bonding material and encapsulated with resin, and a process for the fabrication of such a semiconductor device. Specifically, one preferred embodiment of the present invention is a process for fabricating a semiconductor device, comprising the steps of: (a) attaching a semiconductor chip to a support

member with a die-bonding material, and (b) encapsulating the semiconductor chip with a resin; wherein the die-bonding material comprises a filmy die-bonding material comprising one or more resins selected from the group consisting of silicone resin, acrylic resin and polyimide resin; resin, polyimide resin and epoxy resin; the process further comprising the steps of: (c) mounting said semiconductor chip on the filmy die-bonding material; and (d) attaching said semiconductor chip to said filmy die-bonding material under conditions of a temperature of 150°C to 250°C, bonding time of 0.1 (inclusive) second to 2 seconds, and a pressure of 0.1 to 4 gf/mm².

In another preferred embodiment, the present invention includes a semiconductor device characterized by a support member, a semiconductor chip, and an attaching member for attaching the semiconductor chip to the support member, wherein the attaching member is a cured product of a die-bonding material; the die-bonding material is a film comprising one or more resins selected from the group consisting of silicone resin, acrylic resin, polyimide resin and epoxy resin; and the film has a peel strength of 0.5 Kgf/5 x 5 mm chip or above at a stage where the semiconductor chip has been bonded to the support member.

Applicants point out that various other preferred embodiments are recited in the claims.

The main advantage of the material in accordance with the present invention is that, when manufacturing a semiconductor device and the like, there is a dramatic decrease in the number of defects in the material. Specifically, there are fewer reflow cracks (i.e., essentially none, as shown in Tables 1), which equates to a more durable and reliable semiconductor chip.

The Rejections

Claims 25-28, 32-34, and 40-43 stand rejected under 35 U.S.C. 103(a) as unpatentable over Morita et al. (U.S. Patent 5,406,124). Claims 29, 31, 36 and 37 stand rejected under 35 U.S.C. 103(a) as unpatentable over Morita et al. in view of Yusa et al. (U.S. Patent 5,605,763). Claims 30 and 35 stand rejected over Morita et al. in view of Schuft (U.S. Patent 5,141,050).

Claims 39 and 44-48 have been objected to by the Examiner under 37 C.F.R. 1.75(c) for being in an improper multiply dependent format.

Applicants respectfully traverse the rejection and the objections for the forgoing reasons.

Applicants' Arguments

As an initial matter, Applicants point out that the Yusa et al. reference (U.S. Patent 5,605,763) can not be properly construed as prior art against the instant Application No. 09/785,436 (hereafter, the "Application") because, as supported by the attached declaration by Genichi Matsumoto, dated December 20, 2001, filed in accordance with 37 C.F.R. 1.132, both the Application and U.S. Patent 5,605,763 were commonly owned or subject to an obligation of assignment to the Hitachi Chemical Company, Ltd., of Tokyo, Japan, at the time the invention was made. Therefore, as set forth in 35 U.S.C. 103(c), Applicants have established that the Yusa et al. reference can not be used to preclude patentability under 35 U.S.C. 103 which necessitates that the rejection of claims 29, 31, 36 and 37 be withdrawn. No further comment with respect to the Yusa et al. reference is necessary.

As another initial matter, Applicants believe that claims 39 and 44-48 are in proper format

and should be examined on the merits; however, in order to advance prosecution Applicants cancel claims 39 and 44-48 without prejudice to moot the objection.

Morita et al. discloses an “insulating adhesive tape” that includes a base supporting film and an adhesive layer formed on at least one surface thereof (see Abstract). The adhesive layer is a thermoplastic polymer comprising a thermoplastic polyimide, wherein the polymer has a glass transition temperature ranging from 180°C to 280°C and an elastic modulus ranging from 10^{10} dyne/cm² to 10^{11} dyne/cm² at 25°C, wherein the elastic modulus includes a value ranging from 10^2 dyne/cm² to 10^9 dyne/cm² at a temperature between 250°C and 300°C. Morita et al. discloses that the thermoplastic polymer has a water absorbing ratio of less than 1.2% (col. 9, lines 14-16); however, Morita et al. does not explicitly state to what the percentage is relative. Specifically, Morita et al. only describes % by weight (col. 9, lines 35-39 and lines 53-55); therefore, it is suggested that Morita et al. describes that the water absorbing ratio is less than 1.2% by weight. There is nothing in the Morita et al. reference to teach, or even suggest, that the water absorption of 1.5% by volume or less as required by claims 49, 56 and 58.

Furthermore, Applicants point out that the Examiner admits that Morita et al. does not disclose “a peel strength of 0.5 Kgf/5mm x 5mm chip or above” (emphasis added, Office Action, dated September 25, 2001, page 3, lines 18-21); therefore, it is clear that Morita et al. does not teach all of the claimed limitations of claims 29 and 53. In addition, Morita et al. does not teach the dimensions and geometrical structure of the film as recited in claims 31 and 54.

Applicants submit for the Examiner a Declaration by Takashi Masuko (hereafter the “Masuko Declaration”), dated March 5, 2002, attached herewith and filed in accordance with 37

C.F.R. 1.132. The Masuko Declaration establishes that when the novel film (see Section 7 on page 3) in accordance with the present invention is compared to the prior art film (see Section 6 on page 3) disclosed by Morita et al. under identical experimental conditions, the result is that the novel film of the present invention demonstrates an “unexpected invulnerability” (page 7, lines 4-8). As shown in Table 2, when evaluating the two films for the occurrence of reflow cracks it was shown that while **all** of the Morita film samples under the given die-bonding conditions manifested reflow cracks, **none** of the samples made in accordance with the present invention had reflow cracks. In addition, when peel strength was measured (Masuko Declaration, section 8) the peel strength was significantly greater for the novel film of the present invention over the Morita film (see Table 1). In fact, when the die-bonding condition was set as “250°C x 30gf/mm² x 20 sec,” all of the chips made using the novel film were destroyed during testing because the bond strength was stronger than the chip. In other words, the bond strength of the material in accordance with the present invention was stronger than what this particular test could measure! Clearly, this is another superior and unexpected result.

In addition, Morita et al. does not teach that the filmy die bonding material includes polyimide in addition to the epoxy resin as recited in claim 49.

Thus, the Morita et al. reference can not anticipate, or render obvious, the subject matter of base claims 29 and 31, because Morita et al. does not teach, or even suggest, **a peel strength of 0.5 Kgf/5mm x 5mm chip or above** as recited in claim 29, or the particular dimensions and geometrical structure of the film as recited in claims 31. As all of the remaining claims depend directly or indirectly upon claims 29, 31 or 38, it is clear that Morita et al. can not teach the subject

matter of these dependent claims.

However, even if a *prima facie* case of obviousness can be inferred from the teachings of Morita (which it plainly can not) it is clearly shown that the present invention provides superior and unexpected improvements in both peel strength and reflow crack development over the Morita et al. adhesive tape. Specifically, the peel strength of the novel film in accordance with the present invention is consistently and significantly stronger than the peel strength of the Morita et al. film, and in some cases the peel strength of the instant novel film was so strong that it could not be fully measured using the present techniques. In addition, the novel film in accordance with the present invention was “unexpectedly invulnerable” to the formation of reflow cracks, whereas 100% of the Morita films developed reflow cracks.

The Schuft reference discloses a controlled highly densified diamond packing of thermally conductive electrically resistive conduit that is for use with electrical components (col. 1, lines 7-10). The Schuft reference teaches generally that a thermal conduit made of diamond particles (16) and diamond particles (18) held together by carrier material (20) as shown in Figure 1 can be processed to remove extraneous gases and occluded and/or entrained voids from the polymeric material (18) by the use of any known methods, wherein the resulting conduit should contain little or no void space with a void volume less than 10% is preferable. First, Applicants note that the Schuft reference teaches a thermal conduit for providing thermal transfer between objects (see Abstract) so there is nothing in the Schuft reference to teach that the thermal conduit is suitable for making semiconductor chips. In fact, the Schuft reference teaches that the thermal conduit is used to provide a thermally conductive path between a semiconductor

chip and a heat sink (col. 1, lines 13-19), but there is not teaching that the thermal conduit material is used to make semiconductors. Therefore, the Schuft reference is directed to another field of endeavor. In addition, the teaching of the Schuft reference is vague, only indicating that void volumes less than 10% are desirable without disclosing how to achieve this result.

Clearly, the Schuft reference fails to make up either deficiency of the Morita et al. reference as recited in the present claims wherein the film has **a peel strength of 0.5 Kgf/5mm x 5mm chip or above** as recited in claim 29, or the particular dimensions and geometrical structure of the film as recited in claims 31.

Conclusion


Claim 38 is allowed for the reasons of record so claims 49-54, being dependent directly or indirectly upon claim 38, are likewise allowable. The rejection of claim 29 is untenable because the Morita et al. reference fails to teach a peel strength of 0.5 Kgf/5mm x 5mm chip or above. The rejection of claim 31 is untenable because the Morita et al. reference fails to teach the particular dimensions and geometrical structure of the film. As all of the remaining claims depend directly or indirectly upon an allowable base claim, all claims are allowable. Furthermore, Applicants have provided the Masuko Declaration to establish that the presently claimed invention results in an unexpectedly invulnerable material (i.e. unexpected result).

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Applicants believe that the present claims are in condition for allowance and a prompt Notice of Allowance is earnestly solicited. Questions are welcomed by the below signed attorney for the Applicants.

Respectfully submitted,

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